Chapter

Phonological Deficit Traits in Verbal Language of Dyslexics

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Abstract

Developmental dyslexia is a common learning disorder which is defined as a specific deficit in reading acquisition that cannot be accounted for by low IQ, lack of typical educational opportunities, or an obvious sensory or neurological damage. Dyslexic children commonly present with delayed language development first, which selectively affects phonological processing more than other aspects of language. The problem at the level of phonological representations causes a range of typical symptoms which include problems of verbal short-term memory, non-word repetitions, phonological learning of new verbal information, word retrieval, and rapid naming. This chapter will address the picture of early oral language difficulties especially phonological deficits in dyslexia, and how reading problems are related to them.

Keywords: dyslexia, phonology, oral language

1. Introduction

Failing to acquire an age-appropriate reading level could be due to many reasons; as low intelligence score, lack of proper education or proper home environment, lack of motivation, or presence of sensory deficit. These factors lead to the development of a 'poor reader', but even in the absence of any of the previous causes, learning to read could be laborious, baffling, frustrating, and highly unsuccessful. This is due to a specific reading difficulty, termed dyslexia, which was classified by the Diagnostic and Statistical Manual of Mental Disorders (DSM–5) as a form of neurodevelopmental disorder. Many definitions were presented to describe developmental dyslexia. A simple definition was given by Snowling et al. [1], who described dyslexia as a difficulty in learning to decode (read aloud) and to spell. The International Dyslexia Association characterized dyslexia by difficulties in accurate and/or fluent word recognition together with poor decoding and spelling abilities.

2. Body

2.1 Dyslexia as a language disorder

Dyslexia is coherently language-based. Why? If we cannot speak, we cannot read. Oral language has to come first, then written language could be converted by reading to an oral form. As Shaywitz and Shaywitz [2] put it, the printed characters have no meaning on their own, they have to refer to speech sounds. Unless this

phonetic code happens, the written symbols are just a bunch of lines, circles, and dots. Historically, when this perplexing disorder was identified it was termed 'word blindness'. Adolf Kussmaul used this term [3] to describe stroke patients who selectively lost their ability to read. Later in the 19th century, Pringle Morgan introduced the term 'congenital word blindness', to describe the condition of a boy who found it impossible to learn to read in spite of typical level of intelligence [4]. This concept continued into the mid-twentieth century, with dyslexia still being identified as a hereditary deficit affecting the visual processing of words, and leaving oral and non-verbal intelligence intact [5]. As visual identification of written symbols is only the first step in the story of reading, with the second step related to converting them to oral symbols; the focus shifted to consider dyslexia as a language disorder. Language of dyslexics was later characterized by failure to acquire proper phonological skills [6]. This led to the emergence of the widely accredited phonological theory of dyslexia.

2.2 The phonological theory of dyslexia

This phonological theory of developmental dyslexia postulates that dyslexia emerges due to poor ability of the child to perceive the word as divided into individual phonemes. These phonemes are the ones that need to be matched with their visual counterparts, which are the letters, during reading. This auditory ability of proper perception of phonemes in the same order is known as 'phonemic awareness'. A broader term is 'phonological awareness', as phonemes integrate together to form syllables, each having a characteristic onset and rhyme, then words, and finally sentences. The phonemic awareness can preferably be assessed by getting children to repeat pseudo-words. These are sequences of sounds with no meaning, which the child has to memorize and repeat. Successful development of phonological awareness is considered a strong predictor of later linguistic and reading competence [7].

There is, however, more to phonological deficits in dyslexia than the phonological awareness skill. On a wider phonological scale, dyslexia is also widely thought to be underlaid by a deficit in phonological processing ability [8]. Phonological processing includes phonological awareness, phonological working memory, and phonological retrieval. This only goes to explain that despite intense treatment, some aspects of dyslexia persist into adulthood, as poor spelling [9].

2.3 Phonological sequencing errors in dyslexia

The nature of phonological defects occurring with dyslexia could be evident when the phonological processes in their oral language are analyzed. Peter et al. [10] studied the phonological processes in oral language of adult dyslexics compared to an age-matched control group, with the aim of exploring whether sequential errors were more prevalent than substitution errors. The phonological errors were more evident in nonword repetitions, which is a short-term memory task. They were classified as either errors of phoneme sequence (assimilation, migration, metathesis, deletion, and insertion) or errors of phoneme identity (substitution), with a focus on the type of assimilation used. Assimilatory processes could be either anticipatory or perseverative assimilation. Anticipatory assimilation is the commonly expected form of assimilation and constitutes about 75% of assimilation errors in typical development [11]. It is a regressive form of assimilation where a speech sound becomes similar to another speech sound in the word, anticipated to be spoken after it. The presence of anticipatory assimilation indicates an active motor plan, as the motor plan for the entire word is thought to be set at the onset

of the word [12]. The prevalence of perseverative assimilation, on the other hand, implies an underspecified motor plan and a weak representation of the sequence of sounds in short-term memory.

The whole phonological errors were significantly higher in the dyslexia group compared to a control group, with a special prevalence of sequencing errors in the dyslexia group compared to substitution errors, pointing to a core deficit in processing sequential information. The assimilation was the commonest form of sequencing errors, being more perseverative than anticipatory. There was, in addition, a high percentage of deletions and insertions in the language of the dyslexic group. The same phenomena are interestingly noted in spelling defects in the written language of dyslexics. The dyslexic group was also slower in rapid syllable repetition (diadochokinesis) compared to the control group; a fact also documented by Malek et al. [13].

There is a system of serial order processing or sequentiality related to verbal short-term memory. A defect in this system in dyslexia was pin-pointed by Martinez-Perez [14, 15]. Failure in proper development of phonological awareness may be the cause of the defect in phonological short-term memory, which psychologists term difficulty in creating fine, individualized, well-segmented phonological representations. This short-term memory defect in serial ordering of information in dyslexia is recently gaining attention and psychologists are investigating the presence of selective impairment in it, beyond the verbal domain. This also affects transition of serial information from short- to long-term memory [16, 17].

Adults and children with dyslexia also have sequencing errors in repeating real words, compared to typical adults and children. The words are retrieved from long-term memory rather than from short-term memory, then passed through the phonological component assembly, buffer, motor planning and programming, and motor execution stages. It is theorized that adults with dyslexia have an inaccurately stored phonemic representation of multisyllabic real words in their long-term memory, or encounter difficulty in retrieving this stored information (at the level of motor planning and programming). Evidence for motor planning and programing deficits has been proved by many studies [18, 19]. Research has shown that dyslexics make more errors on phonologically complex stimuli than other typical controls [18].

Common occurrence of unexpected phonological errors in the language of the child in the pre-literacy stage is likely to fall under the diagnostic umbrella of specific language impairment (SLI). At that time developmental dyslexia cannot be yet identified. It is reported that both conditions could be comorbid [20]. Developmental dyslexia could also coexist with attention deficit hyperactivity disorder (ADHD) [21] and childhood apraxia of speech (CAS) [10].

2.4 Morphological defects in dyslexia

Considering that the reading problem in dyslexics is mainly related to a phonological processing disorder, that is reflected on the decoding procedure in reading; is a very simple way to look at it. This is only the beginning of the story of this puzzling dilemma, as reading is not just 'decoding.' The mode of reading is different between beginners and experienced readers. Beginners depend on 'decoding'; they serially correspond each grapheme to the corresponding phoneme then blend the phonemes in the correct order to form the intended word. Here comes the importance of the correct serial order or sequentiality. Experienced readers, on the other hand, read through 'direct access'; they read automatically as most words have been decoded before multiple times and have been integrated in their long-term memory. This allows them to read fast and with ease, focusing on the meaning of what they are reading. Reading, after all, aims at comprehension.

Visual identification of morphemes of the word also takes place during the process of reading development. Studies on typical adult readers indicate that morphological processing is involved in reading [22]. In a word like 'dreamer', the target morpheme 'dream' and the bound morpheme 'er' should be identified with speed and accuracy. There is a sensitivity to morphological structure during visual word recognition. Morphological knowledge contributes to a broad range of literacy skills—reading acquisition, writing acquisition, word recognition, reading accuracy and reading comprehension. Studies of morphology and reading have revealed that dyslexic children and adults score lower than chronologically age-matched controls on morphological tasks, are less sensitive to the internal structure of words, and have difficulty breaking words up into morphological segments. The morphological relationship between stem and pattern with its inflected forms has not been mastered by them [23].

2.5 Early language development and dyslexia

Individuals with dyslexia may also show language problems that extend to vocabulary and grammatical development. In fact, research has shown that the existence of deficits in oral language beyond the phonological component may place children at a higher risk for dyslexia. Authors of the present review, however, believe that all associated language problems probably stem from phonology; the basic units of sounds that are arranged to form syllables, and morphemes. The basic units of language are perceived disarrayed, and the child suffers in forming larger units as morphemes and words.

A study by Scarborough [24] followed the progress of children at high risk of dyslexia because of having one dyslexic parent, at ages of 2–7 years, before they went to school. When the children were 7 and their reading skills could be assessed, it was possible to compare retrospectively the pre-school data of children who became dyslexic with children who did not develop reading difficulties. An important difference between the groups was in their early language skills. Although the dyslexic children used as large a range of vocabulary as their non-dyslexic counterparts at 2.5 years, they made more speech errors and their use of syntax was more limited. At 3 years, the dyslexic children had more difficulty with object naming and at 5, their difficulties in phonological awareness started to become apparent. Their emerging literacy skills were also poorer; they were less familiar with the letters of the alphabet and less competent at matching pictures with print. Scarborough's data are compatible with the phonological deficit theory, but also suggest that the phonological problems, at least of familial dyslexics, may be less specific than is usually supposed, since language skills outside the phonological domain were also affected.

Nation and Snowling [25] denoted that the severity of a child's phonological processing deficit and the integrity of their other language processes predict how well they will learn to read. Another study was done for exploring the early language precursors of dyslexia in a longitudinal study from 4 to 8 years, of children at genetic risk by virtue of having a first degree affected relative [26]. It indicated that the children with significant reading impairment at 8 years, showed a pattern of oral speech and language delay in their pre-school period and poorly developed phonological awareness shortly after school entry. Interestingly, at an earlier stage of literacy development at the age of 6 years, both groups of high-risk children showed difficulty when compared to controls on tasks requiring the use of letter-sound relationships, namely in nonword reading and in phonetic spelling processes. This difficulty was noticed equally in those who did not go on to develop reading problems as well as to those who did. Likewise, Moll et al. [27] and Catts et al. [28]

also showed that children with a family history of dyslexia were more likely to develop dyslexia themselves if they had preschool problems in vocabulary and/or syntax in addition to difficulties in phonology.

As was previously mentioned, phonemes are interwoven to form syllables and words. The problem of dyslexia that starts at the beginning with defective phonological awareness leads to impaired development of vocabulary. This is also reflected on reading. So, the pathway from a phonological disorder in order to reach dyslexia, has to accumulate other factors. These factors as summarized by Snowling and Melby-Levrag [29] were related to vocabulary size and language development, phonological awareness, and letter naming. Viersen [30] studied both word accuracy and word fluency and described two pathways to proper reading. The first, as noted by Caravolas et al. [31], has to do with the preliteracy skills in close association with phonological awareness, phonological skills, and word decoding. The second pathway is through continuous use of language, which fosters the linguistic competence and the reading comprehension, as implied by Storch and Whitehurst [32]. He concluded that word accuracy and fluency were related to three factors: letter knowledge, phonological awareness, and rapid automatized naming (RAN).

2.6 Dyslexia and the brain

Functional MRIs (fMRIs) have shown that processes related to understanding written language are related to many areas in the left hemisphere in the frontal, parietal, temporal, and occipital lobes. The areas that play the most significant role in reading reside in the left parietotemporal and the left occipitotemporal lobes. In readers without dyslexia, the temporal lobe is active in relation to phonological awareness and sound discrimination. The occipital lobe is active to recognize familiar words, while the frontal lobe is active to pronounce words. In readers with dyslexia, there is more activity in the frontal lobe as the child struggles to produce the word, and less activity in the parietal and occipital lobes. The parietal lobe is involved in word analysis and decoding, while the occipital lobe functions to automatically recognize the word for fluent reading [33].

Imaging studies have shown clearly that the phonological impairments in dyslexics are associated with significant abnormalities not only in cerebral connectivity, but also in cortical structure, particularly involving the left hemisphere language network. Researchers have found there is reduced gray matter volume in the left temporo-parietal cortex, middle frontal gyrus, superior occipital gyrus, and reduced regional white matter in bilateral parieto-occipital regions compared with controls matched for age and controls matched for reading-level [34]. The cerebellum was also implicated as some dyslexics struggle with tasks across many domains that are influenced by cerebellar functions, e.g., rapid pointing, and control of eye movements [35]. Recently, the role of the cerebellum in language and reading was established. It is involved in processing nonmotor sequential information including linguistic information [36]. The cerebellum also plays a significant role in infants during speech perception [37], in children and adults during tasks involving syntactic rules [38], and in children during reading tasks [39].

2.7 Persistence of dyslexia into adulthood

Many studies assessed the serial order learning in children and adults with typical and disordered reading ability and showed that immediate recall of serial order was found to be associated with early oral language learning [40]. The capacity for verbal and nonverbal serial order learning was associated with reading ability and phonological awareness [41]. Several studies showed that serial-order learning,

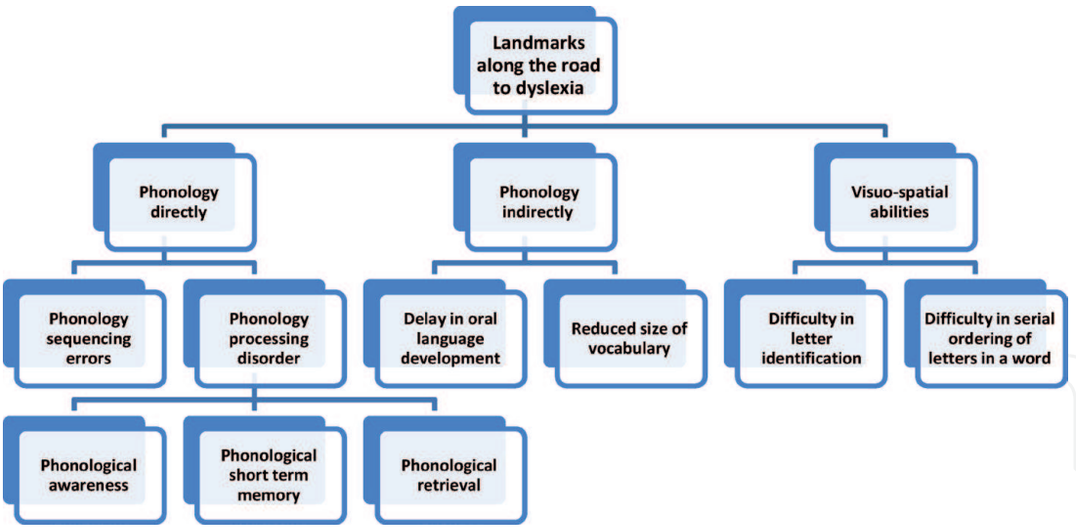

Figure 1.
Landmarks along the road to dyslexia: This figure summarizes the defects that could underlie developmental dyslexia.

both in the verbal and nonverbal modality, was deficient in adults with dyslexia [16, 17, 42]. Similarly, in a study investigating how type of presentation (i.e., simultaneous versus serial) affected recall of visual symbols in a sequence, Romani et al. [43] reported that the adults with dyslexia did not differ from the typical controls in the simultaneous condition but performed significantly worse in the sequential condition.

Transferring sequential information into long-term memory may be an underlying deficit in dyslexia. This deficit persists into adulthood in different modalities, and is evident at the level of the graphemes and the corresponding phonemes in words, leading to the disordered processing of written language characteristic of dyslexia. Although the main feature of spelling errors in dyslexia declines with age and schooling, words with irregular and unpredictable structure, which typical readers have mastered, continue to challenge individuals with dyslexia [44].

According to data revised in this chapter, **Figure 1** summarizes factors that could entangle together to produce obstacles along the way of typical development towards literacy. Although visuospatial perception defects were identified in dyslexia and were formerly thought to be the only cause, phonological defects stem out either directly or indirectly to cast a shade on the majority of factors leading to developmental dyslexia.

3. Conclusion

Several factors interact till reading comprehension is achieved. Letter knowledge is related to visual perception, which cannot be bypassed as a contributing factor. Phonological awareness is at the seat of the problem, as spoken language comes first. Exercises in phonological awareness have been actively integrated in pre-school activities. The focus on lifting up phonological awareness skills should be considered if there is family history of dyslexia. Avoiding language delay should be an important parental target, not only for verbal communication, but also for proper age-appropriate acquisition of reading skills.

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